DOCUMENT RESUME

ED 267 987 SE 046 509

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TITLE Issues Regarding the Establishment of Criteria for the Analysis and Selection of Science Textbooks.
PUB DATE Mar 86
NOTE 54p.; Paper presented at a joint meeting of the School Division-Association of American Publishers, the National Association for Research in Science Teaching and the National Council of Teachers of Mathematics (Atlanta, GA, March 17-18, 1986).
PUB TYPE Reports - Descriptive (141) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Elementary Secondary Education; *Evaluation Criteria; *Science Education; *State Surveys; *Textbook Evaluation; Textbooks; *Textbook Selection

ABSTRACT

The first part of this paper discusses the nature and use of high-inference and low-inference criteria for the evaluation of science textbooks. The second part discusses a project entitled Criteria for the Analysis and Selection of Science Textbooks (CASST). Included are results of a state survey which show that very little emphasis is given to problem-solving in the forms used by textbook adoption committees, that few states use science textbook appraisal forms that are specifically designed for grade level groupings, and that science process skills are not often given much prominence in textbook evaluation forms. Based on these and other findings from the state survey and from eight recommendations offered (such as suggesting that more emphasis on the laboratory-based development of science process skills is needed in the elementary grades), the final section of the paper outlines the basis for the development of high- and low-inference instruments that can be used to analyze (and ultimately improve) science textbooks. Six pages of references conclude the report. (JN)

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ISSUES REGARDING THE ESTABLISHMENT OF CRITERIA FOR THE ANALYSIS AND SELECTION OF SCIENCE TEXTBOOKS

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A paper presented at a joint meetng of the School Division-Association of American Publishers, the National Association for Research in Science Teaching, and the National Council of Teachers of Mathematics, Atlanta, March 17-18, 1986.

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ISSUES REGARDING THE ESTABLISHMENT OF CRITERIA FOR THE ANALYSIS AND SELECTION OF SCIENCE TEXTBOOKS

First basic skills, then teacher competencies, and now textbooks are at the center of attention in the call to reform education in the U.S. In one of the first attempts to look critically at science textbooks, Moyer and Mayer (1985) introduce their analysis of introductory biology texts by saying:

> Former U.S. Commissioner of Education Ernest Boyer wrote in High School: "Most textbooks present students with a highly simplified view of reality and practically no insight into the methods by which the information has been gathered and the facts distilled." Secretary of Education Terrell Bell has described the "dumbing down" of textbooks as a serious national problem. In a "Nation at Risk," the National Commission of Excellence in Education challenged textbook publishers to "upgrade and update textbooks to assure more rigorous content."
>
> Although there is a consensus that textbook quality has declined over the past couple of decades, there is virtually no agreement about either why that decline has occurred or how it might be reversed. (p. 5)

Moyer and Mayer then go on to define science, offer 10 criteria or guidelines to use in selecting quality science textbooks, criticize the Texas textbook adoption process (with biology textbooks as the focus), and then devote 82 pages of their 128 page guide to evaluating 6 general biology texts, 9 academic biology texts, and 3 advanced biology texts. Their efforts to "critically analyze" science textbooks represent an important beginning in what surely will become a widespread response to the call for reform in textbooks used in education. However, there is a very real danger

in using high-inference criteria (i.e., criteria that rely wholly on the subjective judgment of the reviewer) as the only basis for textbook analysis. Ten science educators will bring 10 different sets of values to the task of textbook analysis, resulting in 10 different sets of evaluations. As an example of this, Moyer and Mayer (1985) introduce their section on general biology texts with this statement:

> Although none of the General Biology texts can be considered more than minimally acceptable, one stands out as totally unacceptable: Prentice-Hall's Biology: The Key Ideas contains so many factual errors resulting from hasty or inaccurate generalizations that it misleads students about the living world. It does not include "theory" as a part of the scientific process, uses an outdated systematic approach and emphasizes only human physiology. (p. 17)

When one compares this evaluation with one of the same text by Roach, Milne, and Coyne (1985) that appeared in the 1985 AAAS publication, Science Books & Films, a rather different picture emerges. Of the three reviewers, the college biology teacher (Coyne) had the most positive things to say about the text:

> I like this text a great deal. The authors fulfill their goal of providing a book that introduces science to "science-shy" students in an interesting yet low-key manner. The teacher's manual also reassures and aids the teacher who has a poor science background. The text is concise, direct, and understandable. (p. 280)

We use this disagreement about the quality of a particular biology text as an example of the likely outcome of the use of different, mainly high-inference criteria by reviewers who necessarily have different, perhaps even conflicting values

regarding science, teaching, and learning. A person's evaluations reflect their values. It should be no surprise that applications of high-inference criteria by persons with different value systems result in varying judgments about the "value" or "goodness" or "quality" of the products in question.

Our fundamental thesis in this paper is that both high-inference and low-inference criteria must be used in evaluating textbooks. In the remainder of this paper, we discuss the nature of high- and low-inference criteria, describe a project (Criteria for the Analysis and Selection of Science Textbooks [CASST]) that is directed toward the improvement of science textbooks and related instructional materials, and outline the basis for the development of procedures that can be used to improve textbook analysis and selection.

High- and Low-Inference Models

When one makes judgments about the nature of textbooks, the degree of inference required for most analyses varies along a continuum. If the criterion in question asks the reviewer to determine whether the content of the text is "forward looking", without defining further the meaning of forward looking, the resulting judgments will be well toward the high end of the inference scale. Considerable background knowledge of the science content is required to judge just how "forward looking" is the text, and values about the desirability of such content also are

determining factors in the results of the analysis. High-inference analyses often are directed toward guidelines or criteria that are recognized as important but complex, requiring the analysis and synthesis of many factors.

Low-inference analyses normally results in less variability among raters. The criteria tend to be easier to quantify, requiring fewer value judgments, although considerable knowledge about science content still may be needed. If instead of "forward looking", the text-analysis criterion was accuracy of content, resulting analyses would likely be closer to the low end of the inference scale. Understanding of the science content of the text is required for both criteria, but the judgment about "forward looking" is not needed to determine accuracy of content.

In the introduction, we pointed out the different conclusions about a biology textbook that resulted from apparently careful analyses by two groups of science educators. Knowing the purposes for each review criterion used by each group help to explain how such differences could occur. In the Forward, Introduction and Preface, Moyer and Mayer (1985) let the reader know that they are concerned about the "watered-down" content in current biology textbooks. In addition, they list 10 guidelines (also referred to as criteria) that can be used to select quality science textbooks:

1. Basic concepts and principles of science are covered in a well-ordered synthesis; the book is more than a storehouse of facts.

2. The coverage of science is modern, accurate and linked to the cumulative store of relevant concepts from the past.

3. The point of view is forward looking, opening "vast vistas of unanswered questions."

4. New terms are properly defined, meaningful, and used several times.

5. Development of concepts builds from simple to complex as a logical sequence.

6. Study questions, when provided, are intellectually challenging and trigger more than a regurgitation of facts.

7. A scientific theory is treated as an explanation of a major phenomenon of nature encompassing a broad range of observations.

8. The conclusions of science are backed with evidence and not presented as mere opinions or beliefs.

9. Scientific methods are accurately described and used in presenting the work of scientists.

10. Scientific knowledge is neither eliminated nor muted in response to parochial pressure. (p. 11)

Apparently, it was the application of these criteria that led Moyer and Mayer to conclude that the biology text in question was totally unacceptable.

The biology textbook reviews presented in the AAAS publication were organized in a different way. Figure 1 shows graphically the structure and content of the reviews. The upper matrix identifies 7 criteria that ask for judgments about difficulty or grade level, objectivity by the author(s), accuracy and currency of the content, whether the structure and methods of science are well represented, the extent to which inquiry is encouraged (4 levels), and how well

the text and supplemental materials relate to the student's world (motivation). The lower matrix includes 10 conceptual areas of biology derived by Cho and Kahle (1984) from high school biology texts and the content emphasis of the 1977 National Assessment of Educational Progress study. Written reviews accompanied each reviewer's completed matrices and dealt with "organization" (e.g., how well key topics explicitly are related; how well generalizations are supported by evidence; how well questions focus on key concepts) and "pedagogy" (e.g., comprehensibility of the text for the intended audience; how well study questions test for understanding of key concepts; the extent to which illustrations integrate and/or extend text ideas).

Comparing the Moyer and Mayer criteria with the AAAS criteria used by Roach, Milne, and Coyne and many other science educators reveals some apparent differences in the degree of inference required of the reviewer. However, many of the criteria in the upper matrix in Figure 1 ask for high inference judgments that can be related, directly or indirectly, to Moyer and Mayer's 10 criteria. The lower matrix in Figure 1 would seem to reduce the level of inference required, since the reviewer is simply being asked to judge the adequacy of coverage for each of the 10 conceptual areas. However, even here there is a considerable range on the poor-to-excellent scale among the three reviews. This is, presumably, because each evaluative category (poor, fair, etc.) is left for the reviewer to define. When important-sounding criteria

Evaluator / Criteria	Teacher	Educator	Biologist
Difficulty (grade level)	---	10, 11 average general studies	9 average - below voct - general
Objectivity	fair	adequate	excellent
Acuracy	fair	adequate	good
Currency	adequate	adequate	good
Structure and methods of science	good	excellent	excellent
Inquiry levels (1, 2, 3, 4)	1, 2: good 3, 4: adequate	1, 3, 4: adequate 2: good	1, 4: good 2, 3: excellent
Motivation	adequate	adequate	excellent

Inquiry Levels: 1 - Confirmation; 2 - Structured; 3 - Guided; 4 - Open
T - Teacher; E - Educator; B - Biologist

Key Conceptual Areas	Poor	Fair	Adequate	Good	Exellent
Systematics			T	E/B	
Cell Theory		T/B	E		
Energy Transformations			T/E/B		
Heredity			T/E	B	
Systems			T	E	
Evolution	B		T/E		
Ecology		T	B	E	
Behavior		T/B	E		
Growth/development		T/E	B		
Germ theory	T	E	B		

Figure 1. AAAS General and Specific Biology Content Evaluation.

are used as the basis for analysis, as in the Moyer and Mayer reviews, or when the reviewer is asked to judge the "adequacy" of certain components of a text, as in the AAAS report of reviews of 35 precollege biology texts, the values held by the reviewers are necessarily an important part of their final products. This is neither good nor bad, it is simply the way things are.

In contrast to high-inference evaluations, low-inference analyses rely less on value systems to produce results. Fuzzy descriptors (e.g. very good, boring, exciting, attractive, adequate) are replaced by criteria that are quantifiable in some meaningful sense. For example, Skoog (1984) studied the treatment of evolution in high school biology texts by making word counts of topics concerned with evolution. These quantitative data can be used to make low-inference evaluations about the adequacy of the coverage of evolution, even though the frequency data involve a degree of value judgment. Combining low-inference analyses with high-inference evaluations has recently been supported as a desirable approach to educational research by Howe (1985). He discussed two dogmas of educational research, the fact-value distinction and the quantitative-qualitative distinction, and concluded:

> The quantitative-qualitative dogma has been criticized on two levels. At the level of data, qualitative data are the general foundation of quantitative measurement and are not a priori highly fallible. At the level of inference, any conceptual scheme, theory, or hypothesis presupposes substantive qualitative beliefs that play an inescapable role in drawing conclusions. The consequence is that quantitative and qualitative methods are not incompatible. On the contrary,

> they are inextricably interwoven, and all researchers who advocate combining quantitative and qualitative methods are thus on solid epistemological ground. (p. 16)

Our "high-inference - low-inference" distinction, as applied to textbook analysis schemes, is consistent with Howe's position and is developed in more detail in the remainder of this paper. In the following section we describe a project (CASST: Criteria for Analysis and Selection of Science Textbooks) that is directed toward the development of criteria that can be used to assess the nature of science texts and assist in their selection by state and local adoption committees. And in the final section of this paper we outline the basis for the development of high- and low-inference instruments that can be used to analyze (and ultimately improve) science textbooks.

The CASST Project

Background

During the 1985 annual meetings of the National Science Teachers Association (NSTA) and the National Association for Research in Science Teaching (NARST), work was begun to find ways to improve the quality of science textbooks* used in the U.S. public schools, particularly at the K-8 levels. The NSTA Research Committee suggested that a good way to begin would be to assess the

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*It is emphasized here that the terms "science textbook" refer to all aspects of a curriculum package, including teacher's guides, laboratory guides, workbooks, etc. While the science textbook is currently the most obvious, and perhaps the most influential part of a science curriculum, the other components that normally comprise the curriculum will be included in the CASST Project.

criteria used by states and local school districts to select science texts and related instructional materials. The general project came to be referred to as CASST (for Criteria for the Analysis and Selection of Science Texts) and the first step to assess text selection criteria used in the U.S. was taken in May, 1985, when a letter was sent to each Chief State School Officer requesting information about their state's procedures and criteria used for selecting science texts and related materials. The resulting data were summarized by Good (1985) and formed the basis for discussions at an October 14 & 15, 1985 meeting in Washington, D.C. of the 15-member CASST Advisory Board. Also in October, a proposal for funding various CASST Project activities over a three-year period (1986-1988) was sent to the National Science Foundation. Plans from the Washington, D.C. meeting called for presentations about the CASST Project at the March 1986 NSTA meeting in San Francisco.

Purpose and Significance

Major reports on the state of science education in the U.S. have recommended that the curriculum be improved (Gardner, 1983; Coleman and Selby, 1983; Boyer, 1983; Goodlad, 1983; Sizer, 1984). In a recent assessment of how education can be improved, Resnick and Resnick (1985) said:

> In our view, two elements have the largest role in shaping what is demanded in schools, and therefore what students can be expected to learn. The first is the curriculum - what is taught. The second is assessment - the way we judge what is taught. (p. 5)

Clearly, the nature of the curriculum is a major element in science education in the U.S. Just as clearly, the science textbook is the most powerful influence within the science curriculum. Resnick and Resnick (1985) support this position and refer to a study by the EPIE (Educational Products Information Exchange) Institute (1977) that suggested as much as 95% of classroom instruction is textbook-based. Other published accounts of the influence of the science textbook agree with EPIE's often-cited study (Helgeson, Blosser, & Howe, 1977; Stake & Easley, 1978; Weiss, 1978).

Closely related to the problem of science textbook content is the need for better means to select textbooks. In A Nation At Risk, the problem was described in this way: "In view of the enormous numbers and varieties of texts available, more widespread consumer information services for purchasers are badly needed" (p. 27). More than two years have passed since that statement appeared and little has been done to solve the problem, although recent efforts by Moyer and Mayer (1985) suggest that more attention now is being focused on the problem.

It is clear that improvements in the processes of textbook development and selection must be made if significant progress is to occur toward attaining many of the goals described in A Nation at Risk. Resnick and Resnick (1985) outline the various influences on textbook publishers and suggest that a concerted effort by professional organizations could exert the necessary pressures to change the nature of textbooks and their adoption procedures:

> For example, in just the few years since the call by the National Council of Teachers of Mathematics for greater attention to problem solving in the mathematics curriculum, there is already more space devoted in math textbooks to problem solving. By the same mechanisms that earlier produced lower readability levels, the present national concern for improved standards in the schools can lead to upgrading textbooks. The textbooks can thus become vehicles for improvement of educational standards. (p. 17)

The most important goal of the present three-year project is to achieve reasonable agreement on what criteria are needed to indicate degree of quality of science textbooks. To achieve this agreement by representatives of pertinent organizations, including publishers, science teachers, and school administrators, general consensus must be reached as to what constitutes important and appropriate science content for textbooks. This issue is at the heart of the entire process. Without guidelines for science content, particularly at the pre-high school levels, there is little likelihood that noticeable improvement will occur in the substance of science textbooks.

In addressing problems of establishing criteria for science textbooks, two major questions must be answered:

1. What is the nature of the science content that should appear in science textbooks?
2. How should this content be presented so as to optimize comprehension by students?

The major national curriculum projects of the 1960's (e.g. - ESS, SAPA, SCIS), the cognitive developmental work of many persons, including Jean Piaget and his co-workers, and the more recent

emergence of the cognitive sciences focusing on how students process and learn information, have much to say about possible answers to these questions. Particularly for the first question, answers will result more from a consensus of professional judgments by science educators than from research findings. This is so, simply because of the nature of the question. The term science educator is used here in a broad sense to include school classroom science teachers, university scientists and science teacher educators, and others whose professional expertise allows them to make informed judgments about what science content should be included in school science textbooks.

The second question, on the optimal presentation of content, is more conducive to analysis through the use of research. Recent research suggests characteristics of informational, content area text that affect comprehension and learning (for example, Armbruster, 1985; Commission on Reading, 1985; Jonassen, 1985; Mandl, Stein, & Trabasso, 1984; Meyer & Rice, 1985). Related research in science education has been reported by Champagne, et al. (1981), Eylon and Reif (1984), Finley (1983), Holliday (1981), Leonard and Lowry (1984), and Shymansky and Yore (1979). These and related studies, plus the work of more developmentally-oriented researchers, such as Shayer and Adey (1981), and Lawson and Renner (1975), have implications for the design of student textbooks and will form the basis for CASST criteria on the quality of student textbooks. Research also suggests procedures for teaching children

to learn from reading textbooks (for example, Baumann, 1984; Palinscar & Brown, 1984; Paris, Cross, & Lopson, 1984; Patching, Kameenui, Carnine, Gersten, & Colvin, 1983; Commission on Reading, 1985; Tierney & Cunningham, 1985). This research has implications for the design of instruction and will form the basis of the CASST criteria on the quality of instruction in Teacher's Manuals and other instructional materials.

Survey of the States

Following the recommendation of the NSTA Research Committee, the first step to assess text selection criteria used in the U.S. was taken in May 1985 when a letter was sent to each Chief State School Officer requesting information about their state's procedures and criteria used for selecting science texts and related materials. Nearly one-half of the 50 states in the U.S. have a state-wide mechanism for selecting textbooks that are assigned to a state-approved adoption list.

The survey, conducted by Good (1985), produced a large number of documents, including textbook appraisal forms, science goals and standards, and related information used by states to analyze and select textbooks for placement on adoption lists. Twelve states were selected by Good (1985) to represent the range of procedures used in textbook appraisal processes throughout the U.S. The 13-page report and a 56-page appendix containing sample documents from the 12 states (Alabama, Alaska, California, Florida, Kentucky, North Dakota, Oklahoma, Oregon, Tennessee, Texas, Virginia, and

Washington) were prepared for the CASST Advisory Board. A wide range in the quality and comprehensiveness of the documents was apparent, with some states using brief (20-25 items), general evaluation criteria and other states using extensive evaluative forms (50+ items) that were specifically designed for science textbook evaluation. Very little quantitative (low-inference) analysis was required by any of the forms and, probably, should not be expected of the persons who serve on state or local adoption committees.

The time requirements to analyze a single science textbook using only brief, high-inference evaluation forms are considerable. To expect a member of a textbook adoption committee to devote the time necessary to do thorough analyses (high- and low-inference) of many textbook series is totally unrealistic. In fact, expecting only high-inference evaluations of many textbook series by volunteers who serve on these committees is unrealistic unless adequate time is provided.

Among some of the more interesting bits of information gathered by the survey of the states are the following:

1. <u>Very little emphasis is given to problem solving in the forms used by textbook adoption committees</u>. Although problem solving as a goal for science education receives prominence in various goal statements, there is very little evidence that science textbook adoption committees look for evidence that textbooks emphasize problem solving.

2. Few states use science textbook appraisal forms that are specially designed for grade level groupings. Especially for the early elementary grades, it is clear that very little science learning can occur by having students read textbooks, because of limited reading skills and young chidrens' reliance on concrete, process-oriented learning experiences. The importance of the teacher's guide and other instructional materials is greater at these early grade levels and this is not reflected in appraisal forms.

3. Instructions on the use of textbook appraisal instruments might include example results that have been generated by "experts." Only one of the states (Alaska) used this approach. Each of the various instruments was used by experienced State Department personnel to analyze a particular science text, resulting in analyses that could be used for comparison by science teachers or others on adoption committees.

4. As state science frameworks become more specific, in terms of course content, tying textbook adoption standards and criteria to the frameworks could have a considerable influence on the eventual content of textbooks.

   California and Florida, in particular, have made considerable progress toward development of specific science frameworks that leave no doubt about their importance in the textbook selection process.

In California's document, Textbook Standards - Science, the first standard is typed entirely in capital letters to emphasize its relative importance: CONFORM TO THE CONTENT AND INTENT OF BOTH THE ORIGINAL 1978 SCIENCE FRAMEWORK, AND MORE PARTICULARLY, THE 1984 SCIENCE FRAMEWORK ADDENDUM.

While the trend toward state-mandated science content might have certain benefits within a given state, there is a clear potential for causing considerable difficulties for textbook publishers who normally must produce a single text that satisfies a wide range of content requirements across 50 states.

5. Science process skills are not often given much prominence in textbook evaluation forms. With a few exceptions, Kentucky and Washington for example, most states' guidelines for science textbook appraisal do not have more than an item or two on science processes.

6. Clear, thoughtful descriptions of the philosophy, and goals, of science education were the exception rather than the rule for most states.

Before agreement can be reached on criteria for analysis of science texts and related materials, there must be reasonable agreement about the nature of science and science program goals. The considerable changes in the philosophy and history of science since the work of

Kuhn (1962) should be reflected in science education programs. Recent papers by Macmillian & Garrison (1984) and Siegel (1985) have stressed this point but there is little evidence of these ideas in documents used by school personnel to evaluate science textbooks.

7. The importance of the laboratory as an integral part of the science curriculum is given little emphasis in most appraisal forms. Although few science educators would disagree about the importance of the laboratory in the science curriculum, most textbook appraisal forms devote relatively little attention to this. As an example, Oregon's criteria for the selection and adoption of science textbooks reflected a thoughtful approach, and yet only 24 of the possible 254 points that could be awarded were for laboratory ("hands-on") activities.

8. There is little evidence that research on such thing as comprehension of text material, misconceptions, wait-time, and learning within groups, was used to construct items for textbook appraisal forms.

To the extent that good research bases exists for certain criteria, they should be used to help construct textbook appraisal forms.

The conclusions and recommendations from the survey of the states report by Good (1985) are reprinted here to supplement the previous eight observations.

1. At least two levels of appraisal forms should be developed.

   A higher level that assumes more background knowledge for proper use, and a lower level form not requiring the same expertise. The higher level forms would generate more quantitative analyses which could, in turn, be used in narrative, summary form by local textbook adoption personnel.

2. Appraisal forms should be both science content specific and directed at grade level groupings, such as K-3, 4-6, 7-9, 10-12.

   For specific science courses such as physics, chemistry, and biology, separate forms should be developed. Although the proliferation of many forms could become a problem, the potential for increasing the validity and reliability of assessment for instructional materials suggests that the effort is worthwhile.

3. There should be much more emphasis on problem solving in science, just as there has been increased emphasis on this in mathematics education.

   Criteria to assess important features of instructional materials for this goal would follow from what is known about instruction and learning in problem solving.

4. There should be more emphasis in the elementary grades on lab-based development of science process skills and related knowledge of concepts.

   This emphasis would be reflected in a weighting system used with textbook appraisal forms.

5. The science content in the elementary grades should include primarily the experimental sciences (physical, biological) rather than the theoretical earth sciences.

Rather than seeking a balance among all natural sciences, content should be selected for its ease of development through concrete experimentation. Content-specific appraisal forms would reflect this emphasis.

6. Provision should be made in textbook appraisal forms for state standards, guidelines, etc.

7. Much more emphasis at the elementary grades should be placed on appraisal of teacher's manuals and supplementary materials.

Reading about what scientists have learned over the years can be an aid to science learning only if reading skills are well developed, not a reality for most children in grades K-2 or 3.

8. Consideration should be given to establishing a research center that provides quantitative analyses and interpretations for consumers of instructional materials.

It is curious that product information is available to consumers in nearly every area except instructional materials.

CASST Development and Dissemination

In a reply to Saunders' (1985) comments about a unifying science education theory, Lawson (1985) asked, "Do you suppose a nationwide statement of goals, teaching methods, and specific content objectives is possible? What would be the consequences of such a statement?" Statewide science education goals and specific content and skills objectives are already a reality in a growing number of states. On October 10, 1985 the American Association for the Advancement of Science (AAAS), announced the launching of Project 2061 (the year Halley's comet returns) which will set goals for learning in biological, physical, and social sciences,

mathematics, and technology. This recent effort by the largest professional organization of scientists in the U.S. reflects the trend toward setting national goals for learning.

The CASST Project assumes that a national curriculum already exists in the textbooks used by teachers and, to improve this curriculum, the textbooks must be improved. The main way this will be done is to achieve consensus within appropriate professional organizations on the criteria needed to indicate the degree of quality of science textbooks. Since science teachers are the main target of the CASST Project, the National Science Teachers Association (NSTA) is a key professional organization in the overall plan. Other organizations that are a part of the effort to develop and disseminate criteria needed to indicate the degree of quality of science textbooks and related materials, include the National Association for Research in Science Teaching (NARST), the American Association for the Advancement of Science (AAAS), the National Association of State Boards of Education (NASBE), the Council of Chief State School Officers, the Education Commission of the State (ECS), and the Association for Supervision and Curriculum Development (ASCD). These professional organizations are well represented by the CASST Advisory Board and, especially during the dissemination phase of the project, will make it feasible to reach large numbers of professional persons who have an important interest in science education.

Phase 1 of the CASST Project began with the survey of Chief State School Officers in May 1985 and will continue through 1986 until consensus is reached among CASST Advisory Board members and others about the criteria that indicate quality in science textbooks and related instructional materials. Three publishers were represented at the October 1985 CASST Advisory Board meeting in Washington, D.C. and the publishing industry will continue to be consulted throughout the life of the project. It is anticipated that the "products" of Phase 1 will be in the form of a handbook, including not only textbook appraisal forms and related instructions, but, in addition, will have science education goal statements and information about the nature of science, examples of completed high- and low-inference appraisal forms, selected research summaries of effective use of instructional materials, and related information for the science teacher. The first public forum where the CASST Project will be discussed will be the March 1986 meeting of the National Science Teachers Association in San Francisco. The title of the first symposium, "Content of Science Textbooks: Who Decides?" reflects what is likely to be the most important question that will be raised at the meeting. To what extent should the state departments of education and related state political groups, the publishing companies, the science teachers and related science education professional groups decide on the content of the science curriculum?

Phase 2 of the CASST Project will involve the dissemination of "products" of Phase 1. The products, in the form of handbook, will be disseminated through the various professional organizations. Workshops and seminars at regional and national meetings, special newsletters and publications, and meetings with state and local textbook adoption committees will comprise most of the dissemination activities during Phase 2. Each professional organization (NSTA, NASBE, etc.) will develop its own plan for dissemination, in conjunction with the CASST Advisory Board.

The Basis for High- and Low-Inference Textbook Analysis Models

In our introductory comments we said that in judging the worth or quality of science textbooks, both high- and low-inference analyses should be used. High-inference analyses rely more heavily on value judgments while low-inference analyses tend to involve quantitative parameters. Each approach may be used in an attempt to answer the same general questions concerning science content, nature of presentation, etc. We will argue that an understanding of both science and students are needed, regardless of the approach to text analysis.

In the survey by Good (1985) of various states' textbook adoption criteria and procedures, a number of states apparently had given considerable thought to the importance of students' abilities and interests. California, probably went farther than most in

explicitly pointing out the importance of taking into account the developmental abilities of students:

> Correlate the developmental stages of learners (as defined in the 1984 Addendum) with scientific processes that foster higher level thinking skills at the appropriate developmental level. (Textbook Standard 5)

If taken seriously, this textbook standard (1 of 23) requires those persons on adoption committees to know the developmental abilities of students as well as the scientific processes that foster higher-level thinking skills.

To the extent that science can be learned from textbooks, a third area of importance for analysis is what Armbruster (1985) called "characteristics of a considerate textbook." Guidelines and criteria for text analysis for considerate textbooks have been developed mainly from research based on the information-processing paradigm of learning. Readability formulas, once considered crucial by "experts" in reading, are now seen for what they are - rough, largely misleading numbers that receive far too much attention by textbook publishers and adoption committees. Armbruster, et al. (1985) summarize the sentiment of contemporary researchers:

> Readability formulas exert a powerful influence on American textbooks. Yet evidence is fast accumulating that these formulas may not be very useful in selecting textbooks and that, in fact, they may adversely affect the quality of textbook writing.. (p. 18)

In developing the basis for high- and low-inference textbook analysis models, we consider first the nature of science, then the nature of students, and finally the nature of considerate textbooks.

These ideas are then used to outline analysis procedures and criteria that, when fully developed, could be used to analyze science textbooks and related instructional materials.

The Nature of Science

Those who do science (scientists) and those who study the development and nature of science (historians and philosophers of science) should be in a good position to understand the nature of science. Among the many major statements about science that are well worth considering are those by Margenau (1950), Bridgman (1952), Oppenheimer (1958), Polanyi (1958), Popper (1959), Kuhn (1962), Schwab and Brandwein (1962), Snow (1963), Lakatos & Musgrove (1970), Laudan (1977), Simon (1977), and Feyerabend (1975). By reading these and similar statements about the nature of science, one can begin to see some differences and many similarities in the various descriptions and analyses of this field called science. Although the differences are interesting and many are important to science education, for our purposes here we will look more for the general agreements about the nature of science. For an interesting summary of the nature of science, Margenau's (1950) work in particular, and detailed implications for science education, see Robinson (1968).

One point of agreement on the nature of science is its dual process-product characteristic. It is both a process (really a number of processes like observing, making hypotheses, controlling

variables, etc.) and a body of knowledge (product). Moyer and Mayer (1985) point out this dual nature:

> Science is thus a body of observation with an accompanying explanatory theory. But science is also a process, a method for adding to our accumulating knowledge about the universe and how it works. (p. 9)

The science curriculum projects of the 1960's (SAPA, ESS, SCIS, PSSC, BSCS, etc.) emphasized the dual nature of science and they stressed the inquiry nature of science as well. This search for knowledge about the laws of nature usually begins with a question, as pointed out by Moyer and Mayer (1985):

> Scientific knowledge begins with a question--not surprising since there cannot be answers unless there are questions. Some phenomenon of nature is observed, we become curious about it and wish more information. It is nearly impossible to obtain an answer to any important question in science unless we first make a guess about what the answer might be. (p. 9)

If we agree that science has a dual process-product nature and that inquiry is a second important characteristic, a basis for science education is beginning to appear. The curriculum, including textbooks, should be designed to reflect the process-product/inquiry nature of science. To varying degrees, modern science education curricula are designed to reflect this basic nature of science. However, much of the criticism of science education as practiced in our schools is directed toward the lack of emphasis on the process/inquiry nature of science. Hurd, et al. (1980) reported that inquiry skills are ignored:

> In short, little evidence exists that inquiry is being used. And, further, scant data support the contention that students in biology attain an understanding of science inquiry, or that they can use the skills of inquiry...Biology teachers lecture more than 75% of the time, so little time is left for inquiry. (p. 391)

It seems that the products of science (i.e., the ever-increasing storehouse of facts and concepts about nature) are emphasized by teachers, but the process/inquiry nature of science is given relatively little attention.

While we can and will use the process-product/inquiry nature of science to develop the basis for textbook analysis, we recognize that such a brief, overly-simplistic characterization can lead to misinterpretation. What are the processes of science that should be an integral part of the science curriculum? What are the products in this huge storehouse of knowledge that should be included? How should these processes and products be described and presented to students? These and related questions must be answered before we can judge the quality of science textbooks and related instructional materials.

Inquires into the nature of science since the work of Kuhn (1962) have raised many interesting questions about traditional views of "normal" science, scientific method, paradigms, world views, etc. It is not our purpose in this paper to consider these questions in detail, but rather to form a generally acceptable statement about the nature of science that can be used to develop the basis for textbook analysis criteria and procedures. Our

process-product/inquiry descriptors seem to be a reasonably good beginning. Of the many sources that carry this forward in much more detail, Kuhn (1962) and Robinson (1968) provide very readable and interesting accounts of the nature of science and implications for science education.

The Nature of Students

The nature of a society influences the nature of its educational institutions. In the U.S.A., commitment to the freedom of the individual requires an educational system that must serve both individuals and the society at large. This dual responsibility requires conditions that promote freedom of the mind. In science, the freedom to inquire is essential. The 1961 Educational Policies Commission declared that freedom of the mind is just as essential for nonscientists if our society is to ensure the continuation of our democracy:

> The rational powers of the human mind have always been basic in establishing and preserving freedom. In furthering personal and social effectiveness they are becoming more important than ever. They are central to individual dignity, human progress and national survival...
>
> The purpose which runs through and strengthens all other educational purposes - the common thread of education - is the development of the ability to think. This is the central purpose to which the school must be oriented if it is to accomplish either its traditional tasks or those newly accentuated by recent changes in the world. (From the 1980 AETS yearbook, T. Lawson, editor, p. xiv)

To best achieve this and related goals for all citizens, the educational system must be well adapted to individuals' abilities,

needs, and interests. In short, the nature of students, and in particular those characteristics that are most closely related to learning, must be taken into account by persons who plan, develop, and implement curriculum and instruction. The nature of science, with its emphasis on inquiry and rational thought, seems particularly well-suited to promote the "rational powers" described by the Educational Policies Commission. In the remainder of this section we outline the nature of students, particularly for the cognitive domain, that should be taken into account during the development of textbook analysis criteria and procedures.

Development of Reasoning

Earlier, we raised three questions that must be addressed before the nature of textbooks and related materials can be fairly judged:

1. What are the science processes that should be an integral part of the science curriculum?
2. What are the products (facts, concepts, etc.) in this huge storehouse of knowledge that should be included?
3. How should these processes and products be presented to students?

Simply knowing a lot about the nature of science is not sufficient to answer these questions. We must also know a lot about students. The reasoning abilities of students determine, to a large extent, their abilities to understand much of the content of

science. While it is not possible in this brief paper to go into much detail about students' reasoning abilities, we will summarize some of the important conclusions that seem particularly relevant to our task, and identify a few sources for the interested reader.

In a paper in the 1980 AETS Yearbook, Karplus (1980) provides us with a thoughtful account of science teaching and the development of reasoning. He describes examples of concrete and formal reasoning patterns, most of which are derived from the work of Jean Piaget and the Geneva group of researchers who did so much to help educators understand the importance of cognitive development. In one section on matching subject matter to students, Karplus (1980) gives examples of science concepts that require only concrete reasoning patterns and concepts that require more advanced formal reasoning patterns:

> Particularly valuable for teaching are concepts, such as cell and temperature, that can be either "concrete" or "formal," depending on the meaning used. These concepts can be introduced with their concrete significance during earlier years, while the meaning is elaborated in higher grades to make use of the students' developing ability to apply reasoning patterns at the formal level...
>
> Thus, some of the major concepts in the early grades deal with classification (objects/properties), causality (interaction), class inclusion (systems/subsystems/objects, communities/populations/organisms), serial ordering (life cycle), conservation (keeping track of a system), and transformation (evidence of interaction). All of these are introduced through learning cycles ...that build on the children's own experiences and make reference to objects in the classroom which the children can investigate. In the upper grades, the students come to grips with more advanced concepts such as multiple viewpoints (including self-awareness of the child as observer), transformation (evidence of energy transfer), hypotheses (scientific theory), and multiple interactions (ecosystem). (p. 159)

The learning cycle that Karplus refers to consists of three phases, called exploration, concept introduction, and concept application. Each phase is described and then ten suggestions for the classroom teacher are offered. Further development of these and related ideas can be found in the work of Lawson and Renner (1975), Karplus, et al. (1977), Good (1977), and Shayer and Adey (1981).

In addition to the cognitive development work that has been inspired by Piaget and the Geneva group, recent work with a cognitive science perspective has helped to explain how students learn science. One of the areas of study that has produced interesting results is misconceptions in science. Research studies have shown that students have many misconceptions about physical laws of the natural world; these misconceptions sometimes are referred to as naive theories, (Resnick, 1983). Many of the misconceptions, such as those involving mass, weight, and density or movement and forces or time, velocity, and acceleration or probability, can be traced to earlier work by the Geneva group. However, the more recent work in cognitive science emphasizes the solution of problems within the context of the content domain, such as mechanics in physics, (Trowbridge and McDermott, 1980; Larkin, et al., 1980; McDermott, 1984), or genetics in biology (Stewart, 1982; Smith and Good, 1984). These and related studies show that as misconceptions gradually become incorporated into one's mental model of the natural world, problem solving in science can be inhibited. It is important for the teacher to become aware of common

misconceptions held by students so that attempts to remedy the situation can be made. Obviously the curriculum, including student textbooks and teacher guides, should be structured so as to avoid new misconceptions and correct old ones. Reif & Heller (1982), Posner, et al. (1982), Nickerson (1982), and Mayer (1983) discuss these issues and make suggestions for curriculum and instruction.

There is much research on the development of reasoning in students that can contribute to better science textbooks by ensuring that authors and publishers produce materials which take into account both the nature of science and the nature of students. Both of these areas must form the primary basis for the development of criteria and procedures for the analysis of science textbooks and related materials. Although we have not mentioned the research on the nature of student interaction and learning in small groups, it should not be ignored when considering the nature of students. As Capper (1984) points out:

> The use of small groups has, in many cases, been shown to improve, not only student achievement, but even more substantially, students' willingness to engage in the problem solving process. Student involvement in small group work is consistent with Wittrock's theory of generative learning...which recommends that students be more actively involved in processing information presented in the classroom. Moreover, small group studies have revealed that a student's misconceptions are more likely to be brought to the fore and challenged when students work on solving problems together. (pp. 2 & 3)

Related information on small group learning can be found in Johnson and Johnson (1975), Johnson, et al. (1980), Webb (1982), Lester (1983), Mayer (1983), and Spurlin, et al. (1984).

The nature of students is a complex area of study. To establish optimum conditions for learning science requires that both the nature of science and the nature of students be carefully considered. Earlier in this section on the development of reasoning we raised the question, "How should these science processes and products be presented to students?" In addition to the development of reasoning in students and in their interaction and learning in small groups, a third area of research is important in our efforts to assess the quality of science textbooks. In the following section we take a brief look at research-based ideas related to the question of how science content should be presented in textbooks so as to optimize comprehension by students.

Considerate Textbooks

This section might be placed within the Nature of Students section since students' characteristics clearly are an important factor in determining how they process textbook-based information. However, we have made it a separate section to emphasize its importance in making informed judgments about science textbooks.

To the extent that learning science (remember our process-product/inquiry description) is facilitated by students' use of science textbooks, we should do our utmost to ensure that the

textbooks reflect our best knowledge of science content information processing. While some thoughtful science educators consider textbooks to be, at best, peripheral to good science teaching and learning, especially at earlier grade levels (e.g., see Rutherford, 1983; J. Renner and A. Lawson, personal communication), the weight of the evidence shows that teachers rely heavily on science textbooks and this situation is likely to continue into the foreseeable future.

Characteristics of a "considerate" textbook have been identified by Armbruster (1985) as including a clear and logical structure, obvious main ideas, clear relationships connecting ideas, accurate information, and information that is important to and understandable by students. These ideas grow out of a theory of reading called schema theory:

> According to schema theory, a reader's schema, or organized knowledge of the world, provides much of the basis for comprehending, learning, and remembering information in text. Comprehension occurs when the reader activates or constructs a schema that explains events and objects described in a text. As readers first begin to read, they search for a schema to account for the information in the text, and, on the basis of the schema, they construct a partial model of the meaning of the text. The model then provides a framework for continuing the search throughout the text. The model is progressively refined and constrained as the reader gathers more information from the text. (Armbruster, 1985, p. 47)

Armbruster goes on to identify "textual coherence" as the most important text characteristic:

> The more coherent the text, the more likely it is that the reader will be able to construct a coherent cognitive model of the information in the text. Texts cohere both globally and locally (Cirilo, 1981; Anderson & Armbruster, 1984). Global

> coherence is achieved by text characteristics that facilitate the integration of high-level, important ideas across the entire section, chapter, or book. Local coherence is achieved by several kinds of simple links or ties that connect ideas within and between sentences. (p. 48)

Reading comprehension by students in science courses has been ignored by most research-oriented science educators, as Holliday (1984) pointed out. A few researchers interested in science learning such as Champagne, et al. (1981), Cho & Kahle (1984), Eylon & Reif (1984), Finley (1983), Holliday (1981), and Leonard & Lowery (1984), have begun to focus their efforts in a direction that should call others' attention to the importance of student learning from text. In cooperation with reading researchers such as Anderson et al. (1984), Armbruster (1985), Lunzer (1980), and Pearson (1974-75), the science education community can gain greater insight into how information in science textbooks can be presented so as to optimize student learning. Once students achieve reasonable proficiency with reading skills, reading can facilitate science learning. Whatever the proper role the science textbook should have in the overall science curriculum, good textbooks and related instructional materials in the hands of good teachers can facilitate good science education.

Sample Text - Analysis Criteria: A Place to Begin

High-inference criteria for science textbook appraisal are not in short supply, although there seems to be little agreement about which criteria should be used and how they should be interpreted. Earlier in this paper, we listed 10 criteria used by Moyer and Mayer (1985) to evaluate 18 biology textbooks and we described criteria used by the AAAS to evaluate similar biology textbooks, 35 in all. These criteria plus the many examples described by Good (1985) in the survey of Chief State School Officers provide ample evidence that high-inference criteria are not in short supply. One of the CASST Advisory Board Members, Jane Armstrong, used the report by Good (1985) and work done at the Center for the Study of Reading, Champagne, Illinois, to develop sample criteria that might be used to evaluate science textbooks. Her sample criteria are reprinted here as a concrete place to begin. They are followed by a discussion and consideration of how related low-inference criteria might be developed and used as a part of the process of science textbook analysis.

I. Instructional Design/Organization

A. Is there a logical, easily identifiable organization and structure of the subject matter?

1. Do headings and subheadings reflect a reasonable organization of the subject matter?

2. Do introductions reveal <u>content</u> and <u>structure</u>?

3. Is the structure clearly signaled throughout the text?

B. Does the presentation address only one purpose at a time?

1. Are the main ideas obvious?

2. Is information clearly relative to the main idea?

3. Do transition statements exist to help the reader move from idea to idea?

C. Are there clear relationships which connect ideas?

1. Are connectives explicit or obvious?

2. Are references clear?

3. Is the order of events in the text easy to follow?

4. Are the graphics clearly related to the text?

D. Is the text appropriate for the intended audience?

1. Can the text be understood by the target students?

2. Does the text contain information appropriate for the target students?

E. Is the content accurate?

F. Is there a variety of evaluative techniques, teacher-student evaluation and student self-evaluation?

1. Are there provisions for frequent interim and end of program assessment?

2. Is there a good match between the questions at the end of each chapter and the content?

II. Instructional Strategies

A. Is there a sequential development of concepts through reinterpretation at succeeding grade levels and requiring increasingly more complex levels of knowledge, attitude development and manipulative skills?

B. Does the instruction relate to what students already know?

C. Do examples clearly demonstrate the skill being presented?

D. Is an adequate context provided to allow students to determine meanings of technical terms?

E. Do the authors use patterns of organization (compare-contrast, cause-effect, time order listing) within the writing to assist students in interpreting the text?

F. Provide the learner with opportunities to select from a variety of activities that contribute to the attainment of an objective.

G. Are concepts built from simple to complex in a logical sequence?

H. Are themes developed from chapter to chapter so that students learn how scientific concepts relate to each other?

I. Does the text take into account individual differences?

1. Does reinforcement include reteaching with new, additional techniques or strategies?

2. Do suggestions for enrichment require students to use analyzing, synthesizing, and evaluating skills with new, additional related content?

J. Are the knowledge and skills learned in other disciplines (e.g., computer science, health, reading, social science, spelling and writing) integrated with those abilities that lead to the achievement of scientific goals?

III. Process or Inquiry

Does the textbook:

A. Give learners the opportunity to develop the major processes of science that are employed in scientific inquiry: observing, experimenting, verifying, predicting, organizing, inferring, analyzing, synthesizing, and generalizing?

B. Recognize the importance of communication and cooperation among scientists in their work?

C. Show the difference between fact and theory, between the solid core of verified observation and ongoing intellectual explanation?

D. Make it clear the textbook content is a selection of presently known observation and explanatory theory?

E. Cite unsolved problems in science -- what is unknown in addition to what is known?

IV. Content

(Specific state curriculum frameworks)

V. Using Science

Does the textbook:

A. Demonstrate the role of science and technology in society by showing how significant advancements and contributions of individuals have affected science and ultimately society?

B. Demonstrate that scientific knowledge and technology have been applied to improve people's lives, and have also at times, created problems?

C. Emphasize the importance of scientific knowledge in the student's daily life and his/her role in a democracy?

D. Provide for the discussion of ethical issues in science as an extension of and following the mastery of scientific knowledge and concepts?

E. Show the relationship between people and their environment, and promote awareness of responsibility toward that environment?

F. Develop an awareness of diminishing natural resources, and emphasize the need for wiser management?

G. Identify science-related careers, and stress the importance to a wide variety of occupations?

VI. Supplemental Materials (specific criteria for each need to be developed)

A. Teacher's Manual

B. Lab Manual

C. Study Materials

D. Evaluation Material

Comments on Sample High-Inference Criteria

Section IV in the previous set of sample high-inference criteria is a very important part of any instrument used for science textbook appraisal. The approach taken by the AAAS evaluation of biology textbooks, described earlier in this paper, might be used if sufficient agreement among states could be reached about science content at various grade levels or in specific science courses.

Section VI on supplemental materials (teacher's guide, student lab manual, etc.) also is a very important part of any system for appraisal of texts and related instructional materials. Especially for early grade levels where reading skills are not well developed, supplemental materials are more central to a good science program than student textbooks. In fact, from our earlier description of the nature of science (process-product/inquiry) and from widespread agreement within the science education community, it is clear that even for advanced high school science courses the laboratory should be given a central role in the science curriculum. This should be kept in mind when considering the relative weight given to criteria in the supplemental materials category. As an example of a weighting system used by a "state-adoption" state, Oregon has a science textbook appraisal form (1982) that assigns points in the following way:

I. General Requirements (maximum possible 20 points): These include 4 categories of a general nature such as absence of bias with respect to gender, race, etc.

II. General Content (maximum possible 40 points): Included here are 3 categories asking for general content judgments such as, stimulates student interest, materials are durable, includes answer keys, etc.

III. Specific Content (maximum possible 204 points): Six categories here include 1) compatibility with standards and state goals of education (max. 40 points); 2) laboratory (max. 24 points); 3) promotes independent thinking (max. 28 points); methodology and teaching strategies (max. 40 points); student materials (max. 24 points); teacher materials (max. 48 points).

A few calculations allow one to see that within the Specific Content section, teacher materials rank first (23.5%); compatibility with state standards and methodology and teaching strategies are tied for second (19.6%); laboratory and student materials are next, each with 11.8% of the maximum possible points. The laboratory and teacher materials account for 35.3% of the total. For early grades, these should be given even more weight, for the reasons already mentioned.

Although it may be implied in the example instrument, an emphasis on problem solving is not apparent. Since this is such an important goal of education, the central goal in mathematics

education, it should be given a more obvious place in any system used for analysis of science textbooks and related materials. Probably the most effective way to do this is to devote a subsection within "instructional strategy" to problem solving and assign appropriate weights to the items.

From High- to Low-Inference Criteria

Just as high-inference criteria can suffer from misuse (reliability problems in particular), low-inference criteria have a similar potential for misuse. The best example of this with textbooks is the misuse of readability formulas. When numbers are used indiscriminately to make judgments about the worth of things that inherently involve value systems, the potential for abuse is high. However, when quantitative analyses are combined with qualitative judgments it is more likely that a less-biased, more accurate and sensible evaluation will occur. For example, using the approach of Moyer and Mayer (1985) and the data of Skoog (1984) to make judgments about the adequacy of the coverage of evolution in high school biology texts should lead to more accurate, sensible appraisals than either one or the other. Howe (1985) said, "Ultimate, theory-free, factual knowledge cannot exist, and positivism's corollary fact-value distinction is untenable" (p. 11). The key words here are ultimate, theory-free. A count of the times the word evolution is used in a biology textbook does not seem to be open to disagreement. However, the nature of its use and how

related terms, phrases, pictures, diagrams, etc. are used are important considerations if one is trying to make sensible judgments about the adequacy of the coverage of the theory of evolution in biology textbooks.

High-inference criteria can be operationally defined in terms of low-inference criteria. For example, the portrayal of minority groups and females in science texts is a factor of some importance among current textbook adoption committees. Some states, such as California, devote separate guides to this in an attempt to help textbook adoption committees better judge the presence of bias in writing style, picture content, etc. Most, however, simply include an item such as, the content is free from sexual, ethnic, and racial bias. While this type of criterion seems to involve a clear-cut decision, it would be helpful to have some low-inference (quantitative) results to support one's general judgment. Powell and Garcia (1985) reported such a study in which they coded nearly 6,000 illustrations involving humans in seven elementary science textbook series. They reported interesting results that could be used to help confirm or deny certain high-inference judgments about the content of the textbooks.

Earlier in the paper we emphasized the importance of promoting students' reasoning abilities. It is not unusual to expect members of textbook adoption committees to determine whether the science content of textbooks matches the abilities of students to understand the concepts, theories, etc. This high-inference type of criterion

requires a thorough understanding both of the science content and of the cognitive characteristics of students. This rather demanding task has been undertaken by some researchers such as Good (1977) and Shayer and Adey (1981) using the developmental model of Piaget and the Geneva group. At best, it is a process that yields rough approximations of the goodness of the fit between general capabilities of the students and expected outcomes implied by the content of the text. It is necessary to translate a high inference criterion, that simply directs the user of a textbook appraisal form to correlate students' abilities with content requirements, into more specific characteristics of students at the grade levels of interest. Presumably, these more specific characteristics can then be used to determine whether there is a reasonable match with science content requirements. Shayer and Adey (1981) developed a taxonomy of "different aspects of the development of the child's interaction with the world" that includes categories such as investigation style, reasons for events, use of models, control of variables, and measurement skills. Each of the 15 categories was described in terms of how pre-operational, concrete operational, and formal operational students approach the learning tasks implied by the categories. Their attempt to match the cognitive requirements of certain science-related concepts to the reasoning abilities or schemas of students is a very good example of how a high-inference criterion such as, "Are science concepts reasonably well matched to the capabilities of students," can be more carefully defined and

translated into low-inference criteria.

The expertise and time required to translate high-inference textbook analysis criteria into low-inference criteria are considerable. It is likely that much of this type of work will be done prior to the time textbook adoption committees begin their work. The CASST Project described earlier in this paper is working toward the development of high- and low-inference criteria for analysis of science textbooks and related materials. We think that this project will provide better guidance to those who develop and select science textbooks, resulting in improved curriculum materials for science teachers and students.

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